EEC 4230 Mobile Communication Systems
Tutorial #3

Problem 1

Determine the maximum and minimum spectral frequencies received from a stationary GSM transmitter that has a center frequency of exactly 1950.00 MHz, assuming that the receiver is traveling at speeds of: (a) 1 km/hr; (b) 5 km/hr; (c) 100 km/hr; (d) 1000 km/hr.

Problem 2

Given that the coherence bandwidth is approximated by $B_c \approx \frac{1}{5\sigma_\tau}$, show that a flat fading channel occurs when $T_s \geq 10\sigma_\tau$. Hint: Note that B_c is an RF bandwidth, and assume that T_s is the reciprocal of the baseband signal bandwidth.

Problem 3

If a particular modulation provides suitable BER performance whenever $\frac{\sigma_\tau}{T_s} \leq 0.1$ determine the smallest symbol period T_s (and thus the greatest symbol rate) that may be sent through RF channels shown in Figure. 1, without using an equalizer.

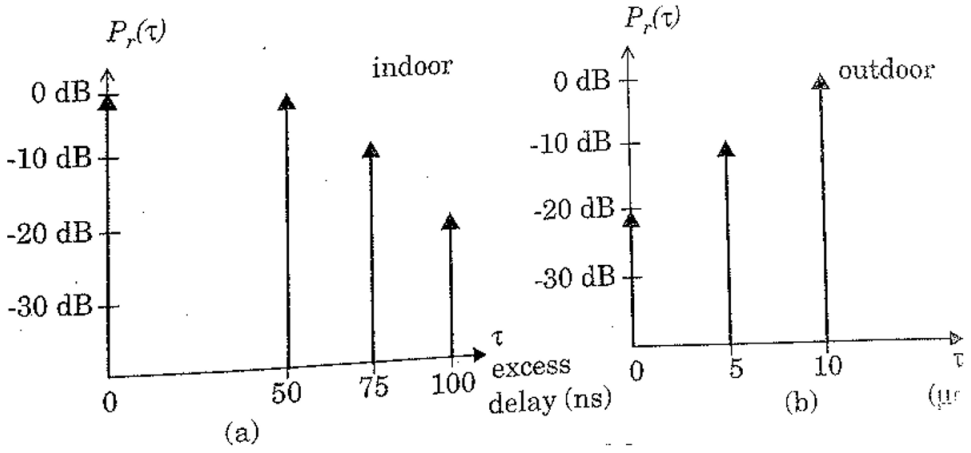

Figure 1: Two channel responses

Problem 4

If a baseband binary message with a bit rate R_b = 100 kbps is modulated by an RF carrier using BPSK, answer the following:

(a) Find the range of values required for the rms delay spread of the channel such that the received signal is a flat-fading signal.

(b) If the modulation carrier frequency is 5.8 GHz, what is the coherence time of the channel, assuming a vehicle speed of 30 miles per hour?

(c) For your answer in (b), is the channel "fast" or "slow" fading?

(d) Given your answer in (b), how many bits are sent while the channel appears "static"?

(e) A CDMA Rake receiver is able to exploit multipath when the channel is (circle all that apply)
(a) flat; (b) slow; (c) fast; (d) frequency selective

Problem 5

For the power delay profiles in Figure 1, estimate the 90% correlation and 50% correlation coherence bandwidths.

Problem 6

Approximately how large can the rms delay spread be in order for a binary modulated signal with a bit rate of 25 kbps to operate without an equalizer? What about an 8-PSK system with a bit rate of 75 kbps?

Problem 7

Given that a Rayleigh-fading mobile radio signal has a level crossing rate of $N_r = \sqrt{2\pi} f_m \rho e^{-\rho^2}$, find the value of ρ for which N_r is a maximum.

Problem 8

Given that the probability density function of a Rayleigh distributed envelope is given by $p(r) = \frac{r}{\sigma^2} e^{\frac{-r^2}{2\sigma^2}}$, where σ^2 is the variance, show that the cumulative distribution function is given as $p(r < R) = 1 - e^{\frac{-R^2}{2\sigma^2}}$. Find the percentage of time that a signal is 10 dB or more below the rms value for a Rayleigh fading signal.

Problem 9

The fading characteristics of a CW carrier in an urban area are to be measured. The following assumptions are made:

(1) The mobile receiver uses a simple vertical monopole.
(2) Large-scale fading due to path loss is ignored.
(3) The mobile has no line-of-sight path to the base station.
(4) The pdf of the received signal follows a Rayleigh distribution.

(a) Derive the ratio of the desired signal level to the rms signal level that maximizes the level crossing rate. Express your answer in dB.

(b) Assuming the maximum velocity of the mobile is 50 km/hr, and the carrier frequency is 900 MHz, determine the maximum number of times the signal envelope will fade below the level found in (a) during a 1 minute test.

(c) How long, on average, will each fade in (b) last?

Problem 10

A vehicle receives a 900 MHz transmission while traveling at a constant velocity for 10s. The average fade duration for a signal level 10 dB below the rms level is 1 ms. How far does the vehicle during the 10s interval? How many fades does the signal undergo at the rms threshold level during a 10s interval? Assume that the local mean remains constant during travel.

Problem 11

An automobile moves with velocity $v(t)$ shown in Figure 2. The received mobile signal experiences multipath Rayleigh fading on a 900 MHz CW carrier. What is the average crossing rate and fade duration over the 100s interval? Assume $\rho = 0.1$ and ignore large-scale fading effects.

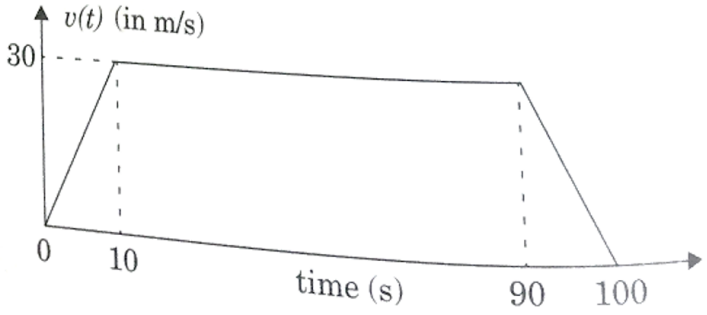

Figure 2: Graph of velocity of mobile

Problem 12

For a mobile receiver operating at frequency of 860 MHz and moving at 100 km/hr.
(a) Sketch the Doppler spectrum if a CW signal is transmitted and indicate the maximum and minimum frequencies.
(b) Calculate the level crossing rate and average fade duration if $\rho = -20$ dB.

Problem 13

For the following digital wireless systems, estimate the maximum rms delay spread for which no equalizer is required at the receiver (neglect channel coding, antenna diversity, or use of extremely low power levels).

System	RF Data Rate	Modulation
USDC	48.6 kbps	π/4DQPSK
GSM	270.833 kbps	GMSK
DECT	1152 kbps	GMSK

Problem 14

Show that the magnitude (envelope) of the sum of two independent identically distributed complex (quadrature) Gaussian sources is Rayleigh distributed. Assume that the Gaussian sources are zero mean and have unit variance.

Problem 15

The local average power delay profile in a particular environment is found to be

$$P(\tau) = \sum_{n=0}^{2} \frac{10^{-6}}{n^2+1} \delta(\tau - n10^{-6})$$

(a) Sketch the Power Delay Profile of the channel in dBm.
(b) What is the local average power in dBm?
(c) What is the rms delay spread of the channel?
(d) If 256 QAM modulation having a bit rate of 2 Megabits per second is applied to the channel, will the modulation undergo flat or frequency selective fading? Explain your answer.
(e) Over what bandwidth will the channel appear to have constant gain?

Problem 16

A local spatial average of a power delay profile measured at 900 MHz is shown in Figure 3

(a) Determine the rms delay spread and mean excess delay for the channel.

(b) Determine the maximum excess delay (20 dB).

(c) If the channel is to be used with a modulation that requires an equalizer whenever the symbol duration T is less than 10 σ_τ, determine the maximum RF symbol rate that can be supported without requiring an equalizer.

(d) If a mobile traveling at 30 km/hr receives a signal through the channel, determine the time over which the channel appears stationary (or at least highly correlated).

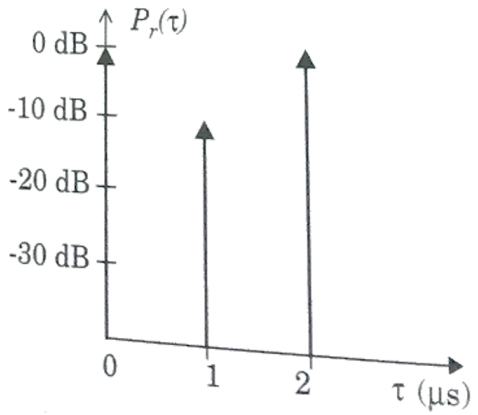

Figure 3: Power delay profile

Problem 17

A flat Rayleigh fading signal at 6 GHz is received by a mobile traveling at 80 km/hr.

(a) Determine the number of positive-going zero crossings about the rms value that occur over a 5 s interval.

(b) Determine the average duration of a fade below the rms level.

(c) Determine the average duration of a fade at a level of 20 dB below the rms value.

Problem 18

For each of the three scenarios below, decide if the received signal is best described as undergoing fast fading, frequency selective fading, or flat fading.

(a) A binary modulation has a data rate of 500 kbps, f_c = 1 GHz and a typical urban radio channel is used.

(b) A binary modulation has a data rate of 5 kbps, f_c = 1 GHz and a typical urban radio channel is used to provide communications to cars moving on a highway.

(c) A binary modulation has a data rate of 10 bps, f_c = 1 GHz and a typical urban radio channel is used to provide communications to cars moving on a highway.

Best Wishes,
Dr. Hussein Seleem